recording instruments. Among the most important of these from the engineer's point of view is the self-recording rain gage.

At a few stations in the northern part of the country the exact rain and snow fall is recorded to the one-thousandth part of an inch, as it falls. At most of the other stations the instruments record every one-hundredth of an inch of rainfall. The duration and intensity of fall of every summer thundershower that passes over the station is accurately shown as well as the rate of fall of the more moderate soaking spring rain.

In addition to the regular stations, which, of course, are widely scattered, there are now about 3,600 cooperative observers, who are equipped with reliable maximum and minimum thermometers and standard rain gages. There are 100 of these cooperative stations in the State of Ohio and nearly that number in Missouri. In California the daily precipitation observations are carefully made at no less than 307 different points.

The results of these observations have previously been published in monthly form, each State in a bulletin by itself. In order to get the rainfall for any station one would need to go through a great many reports. Recently, however, the precipitation data over the limited areas have been compiled and published in a series of separates. The United States has been divided into 106 districts and all the precipitation data in each district, together with the average temperature and wind conditions, published in a single report.

Besides the general discussion and climatological tables these reports contain valuable notes, furnished by the Geological Survey, concerning the water power of the district under consideration. Up to date not quite one-third of the publications have been issued, although all are in the process of preparation. Engineers wishing to know the precipitation over any part of the United States should write the Washington office of the Weather Bureau and ask for the latest publication covering the information. If the separate for that section is off the press it will be sent at once.

Heretofore these cooperative stations have been largely located in the fairly thickly-settled farming districts, and they have been very scattering in the more remote mountain regions. Yet the recent interest in the development of water power and supply reservoirs has brought a special demand for a knowledge of the amount of rain and snow available in the mountains and valleys near the headwaters of the large main streams. And since it is the snow accumulated in drifts in the mountain ravines or packed in forests which is the real source of the water supply used for irrigation, it became necessary to give special attention to the amount of snowfall in the high levels of the mountains of the West.

This was brought about through the cooperation of the United States Weather Bureau, United States Forest Service, and the United States Bureau of Plant Industry, of the Department of Agriculture, and the Reclamation Service and the Water Resources Branch of the Geological Survey, of the Interior Department. This inter-Bureau cooperation plan went into effect July 1, 1908.

The problem of snowfall has been attacked by the establishment of a large number of snow bins throughout the mountain States, together with tree snow scales in the valleys and ravines. Army scouts, forest rangers, guides, stage drivers, travelers on circuits, and all others of like character have been pressed into service to determine the actual snowfall in the first place and then the extent of drifting and packing in the ravines and gulches, and the depth from time to time in the forests and opens. In fact to be able to tell at any time just how much water is available for irrigation and reservoir purposes and to solve the question of when it may be expected to come down the streams.

All this the Weather Bureau is doing and it is now placing the daily rainfall data before the engineer in monthly form by drainage areas instead of by States as formerly.

The country has been divided into 12 large drainage districts and all the precipitation of each district is published in one table, beginning in July, 1909. Separates are issued for each district covering the climatological data, and special papers discussing climatic and water flow topics. All the separates are then bound together and published as the complete MONTHLY WEATHER REVIEW.

Any person can obtain the separate for any particular district, or the complete REVIEW regularly by making application to the District Editor or the Chief of the Weather Bureau at Washington.

As editor of the Missouri drainage area I wish particularly to solicit items and articles of interest from the members of this Club touching on this great problem of Water Resources and Water Conservation.

I wish to commend to your attention the articles that have already appeared in the REVIEW and which I am sure are worthy of your consideration.

The November number for example contains a paper upon the relation between the precipitation, run-off, and discharge in the Tallahatchie drainage district in Louisiana, another on the hydrography of the South Palouse River, Washington, and another upon important problems in climatology.

Some of the papers in the December number are: The effect of drainage work in Northern Iowa on the flood stages of the rivers, by A. Marston, C. E.; The United States Weather Bureau in the work of the engineer, by J. A. Ockerson, of this Club; The agricultural engineer and the Weather Bureau, by Thos. H. Means; and the Rainfall of the Hetch Hetchy Valley, by Prof. A. G. McAdie, of San Francisco.

Our object is to make this MONTHLY WEATHER REVIEW a great engineering magazine and one that shall be the medium through which climatic matters which touch the use of water in any way shall be treated, and with the hearty cooperation of the engineers, which I am sure we can count on, this ambition will be fully realized.

THE PATHFINDER DAM AND RESERVOIR, WYOMING, WITH REFERENCE TO THE CATCHMENT AREA AND ITS WATER SUPPLY.

By L. V. BRANCH, Engineer in Charge.

The United States Reclamation Service, since its organization in 1902, has constructed, for the purpose of storing flood waters for irrigation use, 3 masonry dams which must be classed with the highest masonry dams ever constructed. These are, namely, the Roosevelt Dam on the Salt River in Arizona, the Shoshone Dam on Shoshone River in northern Wyoming, and the Pathfinder Dam on the North Platte River in central Wyoming. This Pathfinder Dam was the first of the 3 to be completed and it, with the resulting Pathfinder Reservoir, is the subject of this article. The location of this dam and reservoir is shown on fig. 1.

The principal dimensions of the Pathfinder Dam are as follows:

Length on top	432 feet.
Maximum height	218 feet.
Width of dam on top	10 feet.
Width of dam at base	94 feet.
Batter upstream face	15 per cent.
Batter downstream face	25 per cent.
Masonry	60 210 cubic yards.

The first stone was set on August 15, 1906, and the last stone June 5, 1909.

The dam was constructed in a narrow box canyon where the North Platte River cuts through a granite ridge about 2½ miles below the mouth of the Sweetwater River, and 47 miles southwest of Casper, Wyo., the nearest railway station.

The dam is constructed of a hard, coarse-grained granite, quarried near the north end of the dam. Both faces of the dam

were laid up in courses of cut stone, but the backing consisted of stones very irregular in shape and size laid on a heavy bed of mortar and the vertical joints filled with concrete.

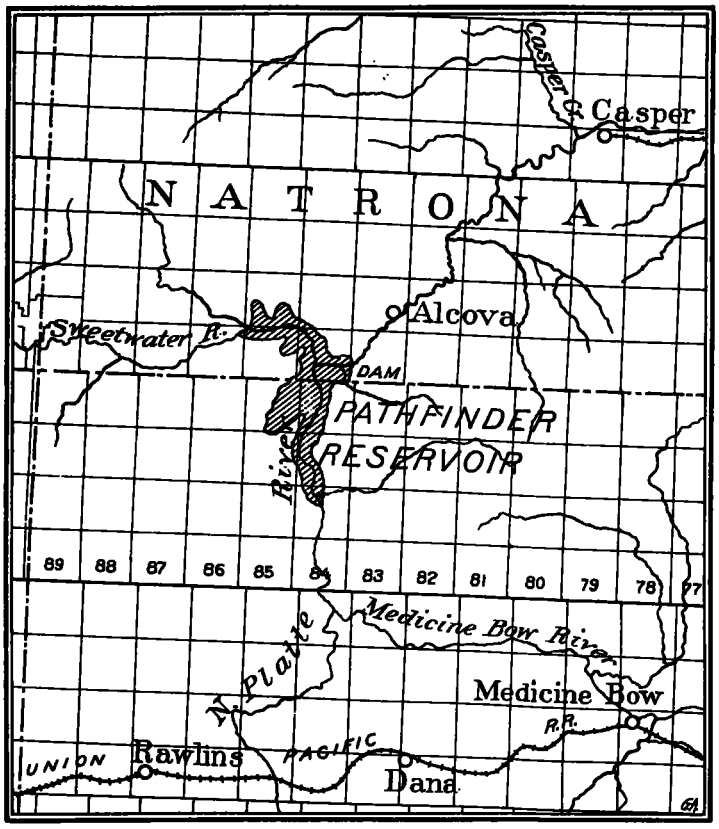

FIG. 1.—Pathfinder Reservoir catchment area.

The accompanying photographs show both faces of the dam, fig. 2 being the downstream face and fig. 3 the upstream face.

The reservoir formed by this dam extends 23 miles up the North Platte River and 15 miles up the Sweetwater River and has a maximum width of about 4 miles. It will contain when filled to the height of the spillway, which is at elevation 5,850 feet above sea level, 1,025,000 acre-feet of water, an equivalent of 334,000,000,000 gallons, and will cover 21,774 acres.

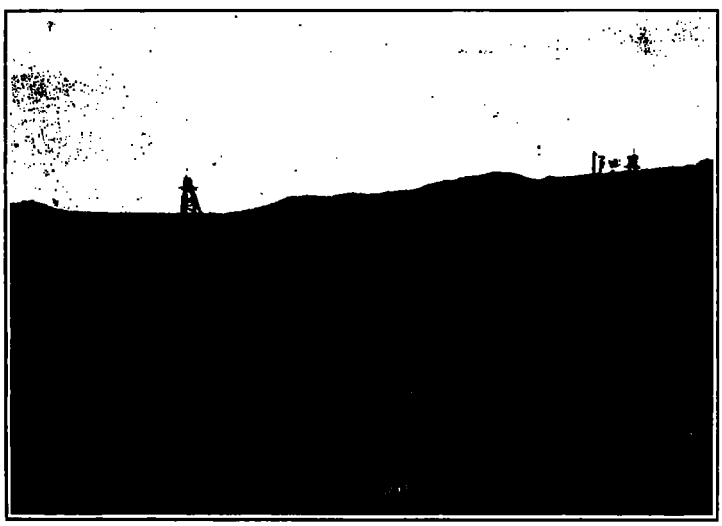

FIG. 2.—Lower face of Pathfinder Dam, December, 1909.—L. V. BRANCH.

The water stored in the Pathfinder Reservoir is now used to water those lands in eastern Wyoming and western Nebraska lying on the north side of the North Platte River and under the Interstate Canal, which canal has been constructed by the Reclamation Service. It is expected that the Interstate Canal will receive future extensions and that other canals will be constructed from the North Platte River until the full flow of the river is put to beneficial use. When the Reclamation Service first investigated the irrigation possibility of the North Platte Valley it was found that during dry years the total low-water flow of the river was used and the only available waters for new canals were the spring floods.

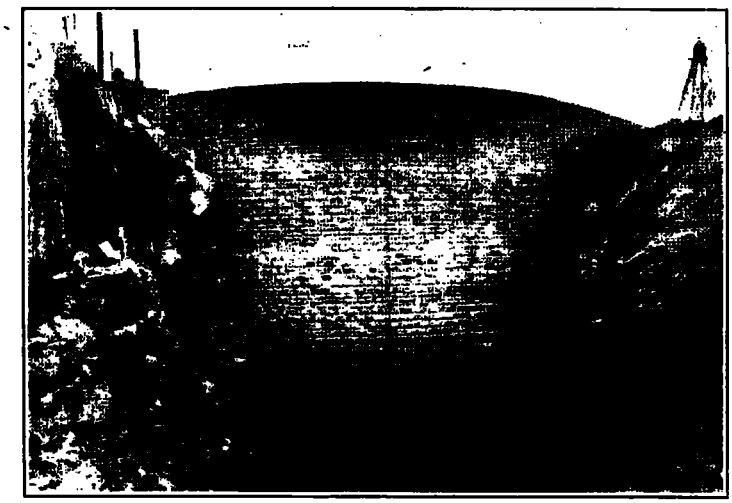

FIG. 3.—Upper face of Pathfinder Dam, December, 1909.—L. V. BRANCH.

The drainage area of the North Platte River above the Pathfinder Dam is approximately 12,000 square miles. The run-off from this catchment basin for the past 4 years, as determined at Pathfinder, is as follows:

Year.	Run-off per square mile.	Depth of run-off.	Run-off.	Discharge.	
				Maximum.	Minimum.
	Cu. ft. p. s.	*Inches.*	*Acre-feet.*	*Sec.-feet.*	*Sec.-feet.*
1906	0.159	2.166	1,385,743	12,090	100
1907	0.211	2.868	1,834,319	12,090	178
1908	0.107	1.47	926,132	6,250	215
1909	0.278	3.776	2,426,180	27,600	375

This run-off, as determined from the records for the 4 years above given, is distributed throughout the year as follows:

	Per cent.		Per cent.
January	1	August	5
February	2	September	3
March	4	October	3
April	9	November	2
May	20	December	2
June	34		
July	15		100

It will be noted that over half of the run-off for the year occurs in the 2 months of May and June. This is due to the fact that the larger portion of the run-off comes from the melting snows in the mountains surrounding the North Park country of northern Colorado and the mountains at the headwaters of the Sweetwater River near South Pass City, Wyo. That portion of the catchment area lying below 8,000 feet is largely sage brush grazing land and furnishes a small proportion of the total run-off. The precipitation in this lower area has been determined at a number of meteorological substations for some years, which stations are still maintained. The precipitation on that portion of the catchment area lying above 8,000 feet above sea level, where the precipitation is largely in the form of snow, is not so well known.

An accurate knowledge of the amount or depth of snow in the high mountains and their foothills, with statements of the condition of the surface of ground when the snow first covered same and additional information as to whether the snow is loose or well packed, will render it possible to predict with considerable accuracy the run-off for the year. It is hoped that the Weather Bureau will be able to secure such data as to the snowfall at a number of stations in high altitudes so that the Reclamation Service may have at hand accurate information on which to regulate the Pathfinder Reservoir to the best advantage.

This regulation of the reservoir will also require a knowledge of the evaporation from the surface of same, and it is hoped that the Weather Bureau and Reclamation Service can cooperate to secure such records.

The Pathfinder Dam and Reservoir are parts of the North Platte Project, of which Mr. Andrew Weiss is Project Engineer and Mr. R. F. Walter, Supervising Engineer.

PROTECTION OF FRUITS FROM FROST, ETC.

Letter from the Secretary of the Missouri State Board of Horticulture to the Section Director at Columbia, Mo., and remarks by the latter.

I heartily agree with you that there ought to be close cooperation between the Weather Service and the various Departments of Agriculture. I certainly hope that in the near future it will be possible for the Weather Bureau to make a careful study of the reasons for crop failures, particularly fruit, in certain regions. In Missouri certain sections, for no apparent reasons based on topography or isotherms, nearly always escape injury. I particularly have in mind the famous peach region about the town of Koshkonong in Oregon County. As usual, that section suffered no injury from the blizzard of mid-April. The peaches at Koshkonong were absolutely unhurt. The peach district there extends a short way into Howell County, but I think not farther than Brandsville, as I know practically all of the fruit was destroyed in the northern and western parts of Howell County. This specially favored district seems to extend east into Ripley County, at least at Doniphan there was very little injury from the blizzard of April 24. However, at this place the fruits were badly winterkilled, whereas at Koshkonong there was no winter injury. However, I should explain that even in the vicinity of Koshkonong poorly kept orchards, or those located in low ground were injured by the cold weather of the winter.

The value of knowing the definite reasons why Koshkonong is such a favored place for fruit growing lies in the fact that there may be other regions just as good as the one spoken of; also if we knew why Koshkonong is favored above other places we might be in a position to give definite advice about the location of orchards in many parts of the State which have not been tried and, perhaps, on theoretical grounds, we might be able to forestall failures which are inevitable, owing to certain natural conditions of topography, physiography, temperature, etc.

It may not be possible to secure any definite information along the line I have mentioned without having a number of volunteer observers in and around the special districts to be studied. If it were feasible to undertake certain "climate surveys" of this kind, some very interesting statistics, I feel sure, would be quickly forthcoming.

Another line of work in which the fruit grower must look to the Weather Bureau for assistance is the matter of frost warnings in connection with the heating of orchards. Orchard heating is a new thing in this State and by no means old in other States. The great difficulty now in the way of heating orchards economically is that the growers either do not know the exact time at which to light their heaters, or being somewhat uncertain about the matter, become excited or, whatever the case may be, they light the fires too soon. In many instances the temperature does not fall quite low enough to make it necessary to light the fires, but not knowing the danger point within a matter of 2° or 3°, a great deal of fuel may be consumed unnecessarily. Under such circumstances the grower finds that his neighbor who did not heat his orchard had just as much fruit as he did, and so loses faith. We have determined the exact temperatures representing the danger point at the different stages of development of fruit from the time the buds are dormant to the time the young fruit is of considerable size. It seems to me that it might be quite possible for the Weather Bureau to warn fruit growers, even in remote districts, of frosts and freezes in ample time for them to get everything ready for heating their orchards.

REMARKS BY GEORGE REEDER, SECTION DIRECTOR, IN CHARGE OF THE MISSOURI SECTION, U. S. WEATHER BUREAU.

The suggestion of Professor Howard that the Weather Bureau make careful study of the temperature effects in connection with the fruit crop with a view of ascertaining, if possible, why some localities appear to be more immune from killing frosts than other near-by regions is, while not new, an interesting one, and if followed out might lead to some valuable information that would be useful to the fruit grower.

The climatological records of southern Missouri probably cover too short a period of time to enable one to form a correct opinion as to whether Koshkonong lies within a "thermal belt" or "verdant zone." The data that we have however indicate that the locality in question is not appreciably more favored as regards weather changes than its neighbors.

Table 1 gives the average date of the last killing frost in spring, the latest date on which a temperature of 32° F. occurred, and the number of times that freezing temperatures occurred as late as May, at all stations in the southern tier of counties situated in about the same latitude as Koskhonong, from McDonald County on the west to Ripley County on the east, a strip of country averaging about 25 miles wide and 200 miles long.

TABLE 1.

County.	Station.	Latitude, north.	Longitude, west.	Elevation.	Record, years.	Average date of last killing frost in spring.	Latest date on which 32° F. occurred.	Year.	Number of times 32° F. occurred as late as May.
		° ′	° ′						
McDonald	Dean*.....	36 39	94 21	1000	12	Apr. 21	May 5	1906	3
Barry.....	Mineral Springs†	36 41	93 48	1475	12	Apr. 15	May 20	1894	2
Taney.....	Protem‡.....	36 32	92 52	1000	5	Apr. 20	May 4	1903	1
Howell.....	Olden.....	36 50	91 54	1246	17	Apr. 16	May 9	1906	2
Oregon.....	Koshkonong....	36 36	91 38	911	10	Apr. 16	May 1	1903	1
Ripley.....	Doniphan.....	36 37	90 49	440	7	Apr. 19	May 2	1909	1

*Near Anderson, P. O. †Closed in 1905. ‡Closed in 1906.

We find from the foregoing table that the section of the country extending from Koshkonong, and probably some little distance westward of that town, eastward to Doniphan, has but a slight advantage over the sections more to the northward and westward. The average date of the last killing frost in spring at Olden and Koshkonong (the latter being 20 miles farther south) is the same for 17 and 10 years, respectively. Freezing temperature has occurred at Olden as late as May, twice in 17 years, and once at Koshkonong in 10 years. It is true that a freeze occurred at a later date at Olden than at Koshkonong, but that can be accounted for by the difference in latitude and elevation. Similar differences at stations farther west may be accounted for in the same manner, including longitude, as the western part of the State is usually colder than the eastern part when averages are considered. In other words, the climatic factors in the region between Koshkonong and Doniphan do not vary more than one would expect for the latitude and topography.

The apparent immunity of orchards in this region, especially in the neighborhood of Koshkonong, from damaging tempera-